Development of Robotic Ocean Carbon Observers

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RESEARCH OBJECTIVES

The ocean's biological carbon pump (photosynthetic fixation of dissolved inorganic carbon in surface waters and downward transport of fixed carbon into the deep sea) plays a critical role in the ocean's carbon cycle and partially determines concentrations of atmospheric CO_2. Marine photosynthetic organisms reproduce and are eaten on the time scale of hours to days. Knowledge of the biological pump is therefore severely limited because most oceanographic observing and sampling methods cannot obtain data efficiently on these short-time scales. Our objective is to develop methods for observing carbon biomass variability on spatial and temporal scales that match biological processes in the oceans.

It is important to understand the variability of particulate organic carbon (POC) and particulate inorganic carbon (PIC) because formation of these phases during photosynthesis reduces and enhances, respectively, the concentration of dissolved molecular CO_2 in the waters in which these organisms grow. PIC-producing organisms (coccolithophores) sometimes occur in blooms that are readily visible from space. Reflective waters reduce the capacity of the ocean to absorb solar radiation; such blooms have negatively impacted fisheries.

APPROACH

We are developing sensors for carbon biomass which will be added to new low-cost autonomous robotic floats and gliders that are capable of profiling to mid ocean depths (Figure 1). The optical basis of measuring POC is established and we are now working on a birefringence sensor for PIC. The new sensor uses the fact that PIC is dominated by carbonate minerals (calcite and aragonite) which have extremely high birefringence (measure of the ability of the mineral to interact with and change polarized light) compared to other commonly occurring mineral particles in seawater. Furthermore, PIC dominates the concentrations of mineral particles in most oceanic regimes.

Figure 1. The Sounding Oceanographic Lagrangian Observer (SOLO). More than 1,000 profiling floats like SOLO have been widely deployed in the oceans for ocean temperature, salinity and circulation observations. LBNL is developing carbon biomass concentration sensors for the SOLO. (Photo courtesy of Russ Davis, Scripps Institution of Oceanography).

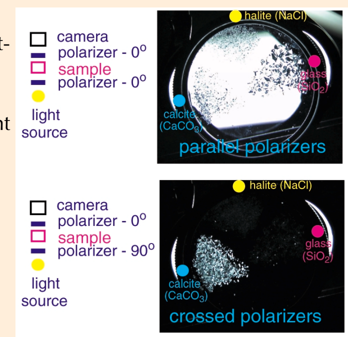

Figure 2. Photographs illustrating calcite birefringence compared with non-birefringent halite and glass. Calcite lights up when polarizers are crossed.

ACCOMPLISHMENTS

The concept of our PIC sensor has been demonstrated in the laboratory (Figure 2). We have measured birefringence of suspensions of calcite in water in the presence and absence of non-birefringent particles. PIC may be readily determined in seawater using a commercial bench-top spectrophotometer adapted with linear polarizing filters.

SIGNIFICANCE OF FINDINGS

We have designed sensors which will measure the two components of carbon biomass in ocean water, and when attached to newly developed robotic profiling flats and gliders, will permit a major improvement in ocean biomass observations. These observers are inexpensive enough to be widely deployed in the oceans to follow the natural carbon cycle and perform observations during and after small-scale experiments to study ocean ecosystem response to ocean fertilization.

RELATED PUBLICATIONS

Bishop, J.K.B., S.E. Calvert and M.Y.-S. Soon, Spatial and temporal variability of POC in the northeast subarctic Pacific, Deep-Sea Research II, 46(11-12) 2699-2733, 1999.

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Bishop, J.K.B, and R.E. Davis, Autonomous observing strategies for the ocean carbon cycle, ENERGY 2000, The beginning of a new millennium, P. Catania, B. Golchert, C. Zhou, eds., Publ. Balaban International Science Services, L'Aquila, Italy. pp 1256-1261. ISBN 1-58716-016-1, 2000.

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